

# (12) UK Patent Application (19) GB (11) 2 279 613 (13) A

(43) Date of A Publication 11.01.1995

(21) Application No 9313757.8

(22) Date of Filing 02.07.1993

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(51) INT CL<sup>5</sup>

G06K 19/077

(52) UK CL (Edition N )

B6A AC91 AK

(56) Documents Cited

None

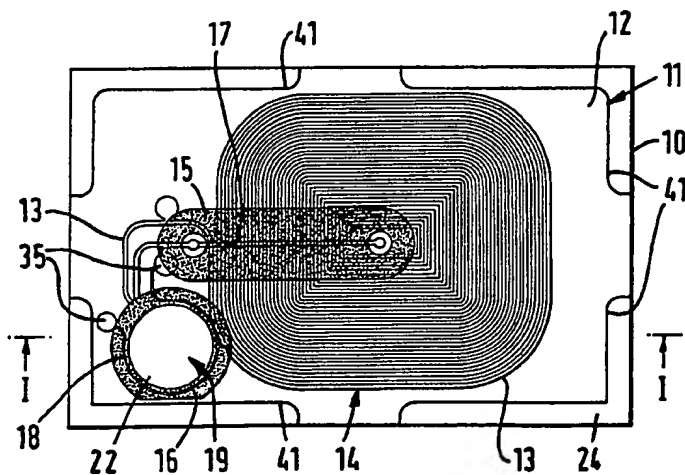
(58) Field of Search

UK CL (Edition L ) B6A AK  
INT CL<sup>5</sup> G06K

(54) Integrated circuit or smart card

(57) A method of manufacturing a smart card comprises removing portions of a printed circuit substrate 11 corresponding to peripheral corner regions of a card such that protective layers 24 on either side of the printed circuit are bonded to each other thereby reducing the likelihood of de-lamination of the card. The shape 41 of the printed circuit is cut out by stamping.

FIG. 3



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1/5

FIG. 1

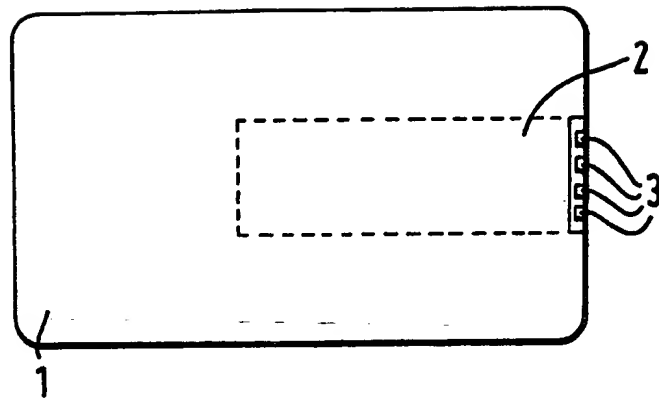
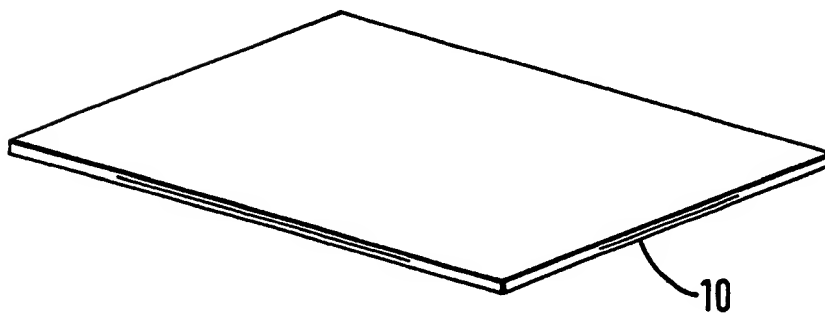


FIG. 2



2/5

FIG. 3

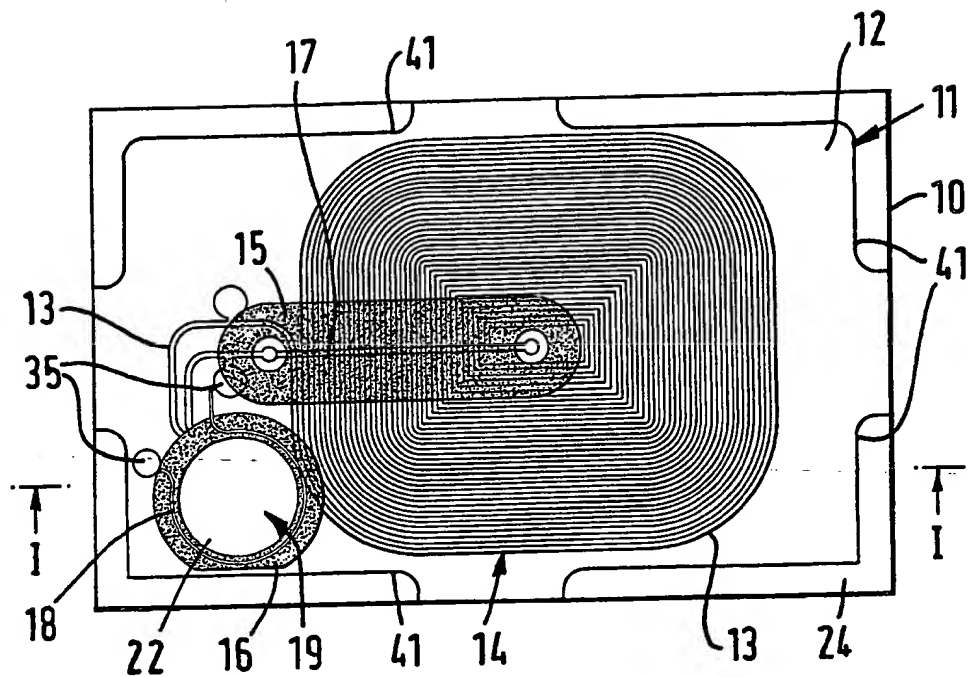


FIG. 4

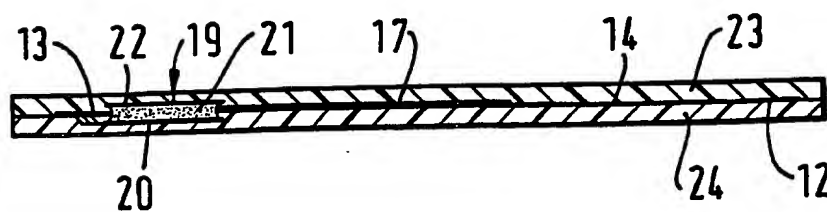


FIG. 5

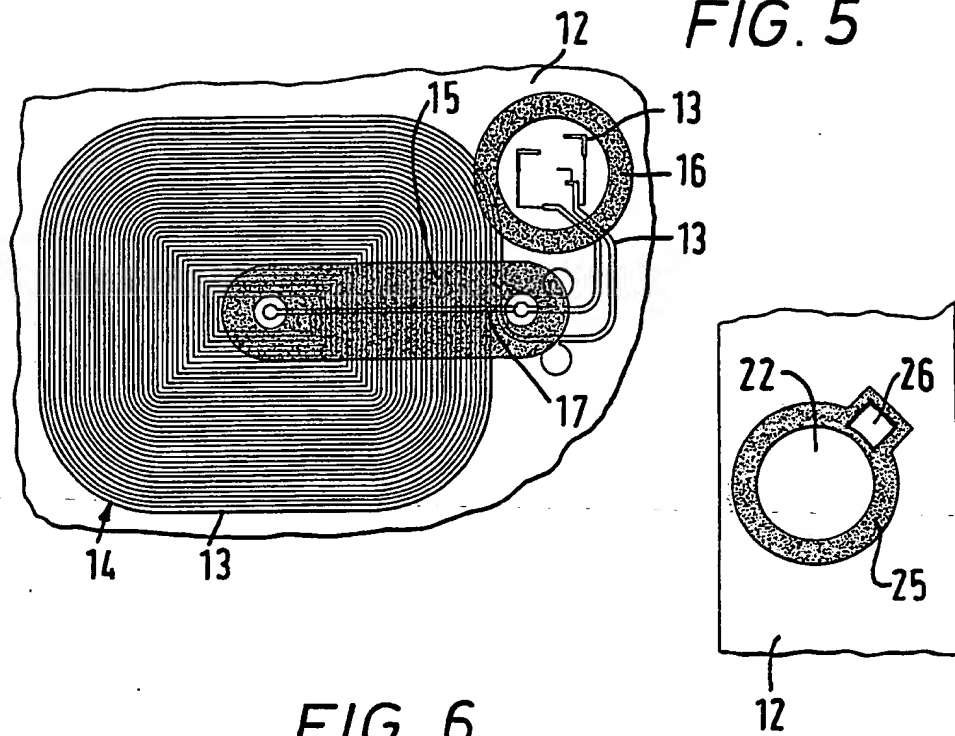
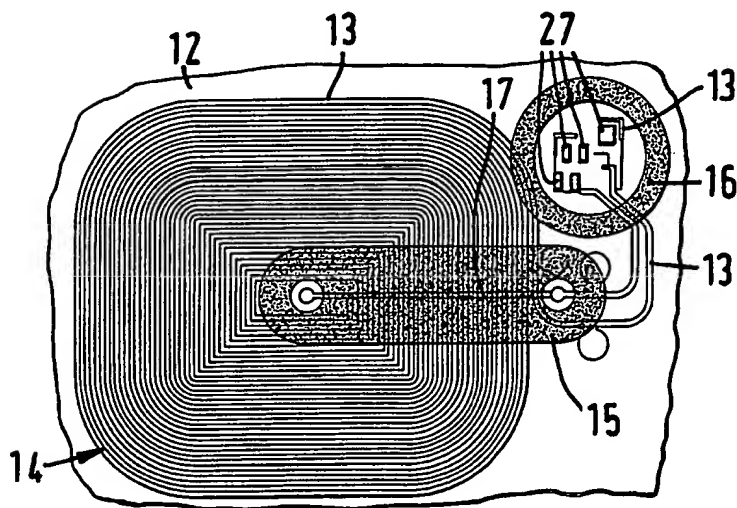


FIG. 6



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FIG. 7

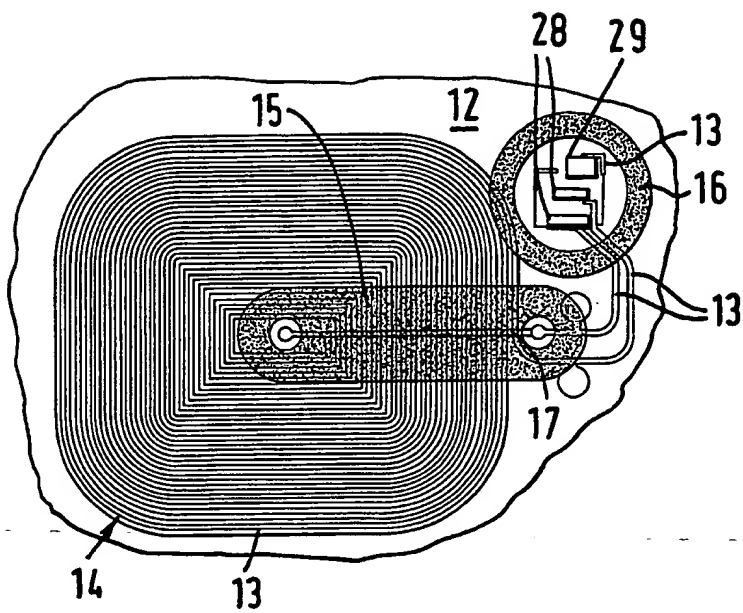
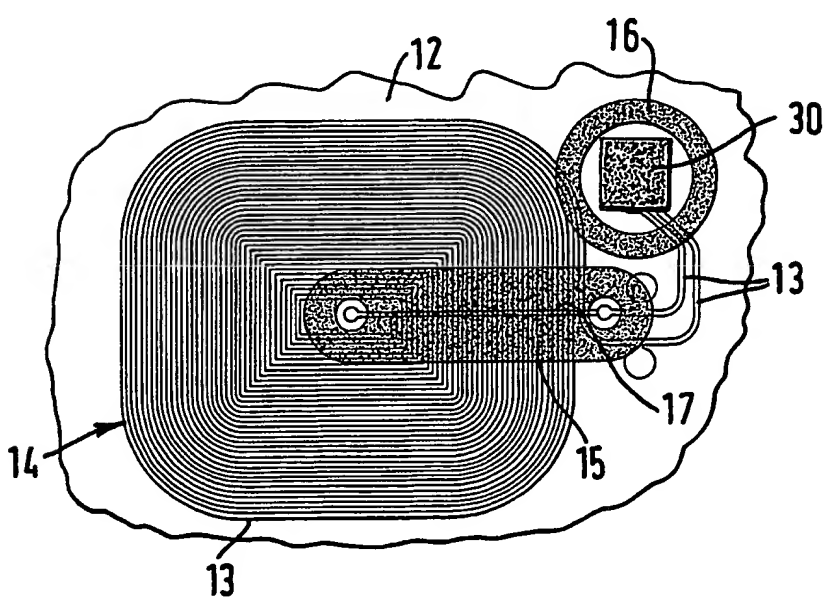


FIG. 8



5/5

FIG. 9

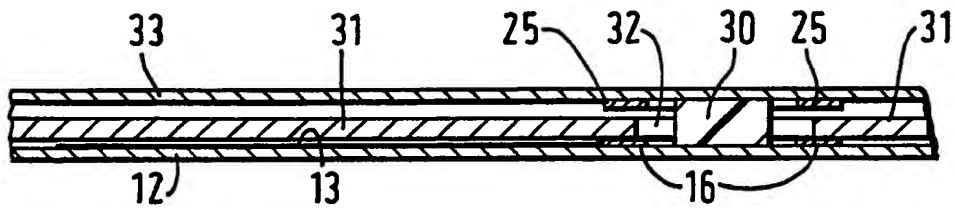


FIG. 10

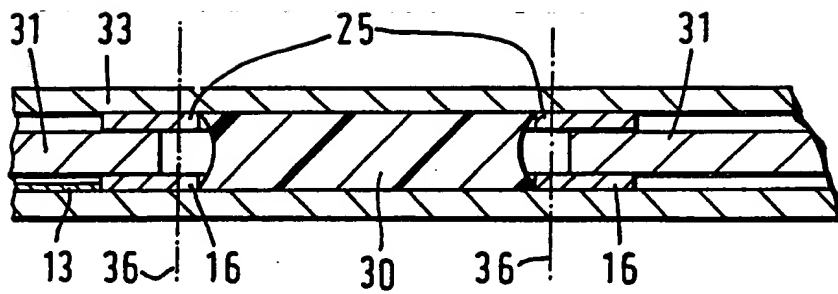
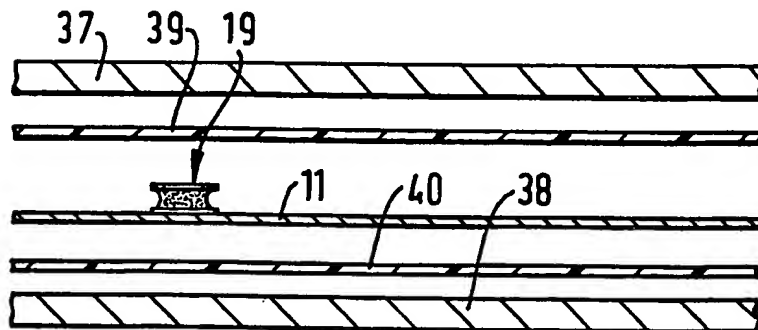


FIG. 11



**A METHOD OF MANUFACTURING A CARD**

This invention relates to a method of manufacturing a card of the type comprising a printed circuit sandwiched between protective layers and in particular, but not exclusively, to such cards which are subjected to stress, for example what are commonly referred to as "plastic cards", that is such cards which are carried by individuals and used for such purposes as recording or authorising transactions and/or for authorising entry to buildings. (Note that the term "printed circuit" as used in this specification should be considered to refer to any system of conductive tracks on an insulating substrate, whether such tracks are formed by printing, etching, vapour deposition or any other technique.)

One previously proposed type of "intelligent" plastic card or "smart card" is illustrated in Figure 1 and comprises a plastic carrier card 1 in which is embedded a printed circuit carrying various components, connections being made by contacts 3 with a suitable communications unit. In such cards the printed circuit 2 which is embedded below the surface of the card is normally relatively small compared to the total surface area of the card. However there is now a requirement for larger printed circuits within cards particularly if the card communicates with external circuitry by means of an inductive loop embedded within the card, for it is desirable that the loop be as large as possible and therefore almost the whole area of the card is required for the printed circuit. Because of this and also to simplify production it has previously been proposed to manufacture such cards by forming a plurality of circuits on a single

- 2 -

substrate, bonding layers of protective material to either side of the substrate and then stamping out the cards. However, it has been found that cards produced in this way tend to delaminate as a result of the flexing that such cards receive in everyday use.

According to the present invention there is provided a method of manufacturing a card comprising a printed circuit sandwiched between protective layers, the method comprising: removing portions of a substrate of the printed circuit in regions to correspond to the periphery of the card; sandwiching the printed circuit between the protective layers, which layers extend over the regions where the portions have been removed; bonding the protective layers and substrate together; and cutting the card out of the protective layers, the cut extending through the substrate in those regions of the periphery where the substrate has not previously been removed.

By employing the present invention at least part of the peripheral regions of the cards do not have an intervening printed circuit between the protective layers, enabling the protective layers to bond to each other providing regions around the periphery which are more resistant to de-lamination. It has been found convenient to remove the portions of the printed circuit, and to cut out the card by stamping.

The method is particularly advantageous where a number of circuits are formed on a common substrate wherein the portions are removed simultaneously from all the circuits on that substrate.



- 3 -

Advantageously the cards are polygonal and the portions removed correspond to the corner portions which are more susceptible to de-lamination than other portions. If the cards are rectangular, as is conventional, cruciform portions are preferably removed corresponding to corner regions of four adjacent cards.

The bonding between the layers is preferably achieved by intervening layers between each of the protective layers and the substrate, which intervening layers are coated with adhesive thereby bonding the layers together. These intervening layers are advantageously layers of polyester which has a high tear resistance and prevents components mounted on the printed circuit from "breaking out" of the protective material which would typically be pvc.

One embodiment of the invention will now be described, by way of example only, with reference to Figures 2 to 11 of the accompanying drawings in which like numerals have been used to indicate like parts, and of which:

Figure 1 schematically illustrates a previously proposed arrangement (not in accordance with the invention) of electrical components in a plastic card;

Figure 2 is a perspective view of a plastic card in accordance with the present invention;

Figure 3 is a plan view of the card of Figure 2 having its top sheet 4 removed

- 4 -

to reveal the printed circuit;

Figure 4 is a cross-section through the card along the line I - I of Figure 3; and

Figures 5 to 11 illustrate various stages in the production of the plastic card depicted in Figures 2 to 4.

Referring first to Figure 2 there is shown a perspective view of the final card which has the same external dimensions as a standard "plastic card". The card contains an integrated circuit. On Figure 2 it is possible to see edge portions of a substrate of the integrated circuit, exposed at a central part of each edge of the card. The integrated circuit communicates with interrogation units via an inductive link located at appropriate locations. The integrated circuit would normally contain a memory device and could be used for any number of purposes, for example recording banking transactions or recording zones of buildings etc to which entry has been gained by use of the card as an identity card.

Referring to Figure 3 there is illustrated a plan view through a section of the card 10 of Figure 2 in the plane of the card. From this and the cross-section along line I - I illustrated in Figure 4 it can be seen that a printed circuit 11 comprises epoxy/glass substrate 12 and conductive tracks 13, a substantial portion of which form conductive loop 14. Darkly shaded regions 15 and 16 comprise of a thermoset dielectric material. The purpose of the region 15 is to insulate a silver conductor 17

- 5 -

from the inductive coil 14. The purpose of dielectric layer 16 will be explained later.

An integrated circuit and capacitive components, not shown in Figures 3 or 4, are contained within a capsule-like element 19 which is separated by cut 18 from the rest of the substrate 12. The region 20 of the substrate 12 is lowered below the plane of the printed circuit 11, the integrated circuit and capacitive components being located in potting compound 21 sandwiched between the portion of the substrate 20 and a capping portion 22 of the same material as the substrate 12.

The printed circuit 11 and element 19 are sandwiched between two outer sheets 23 and 24 of PVC thermoplastics material and two intervening layers (not shown in Figures 3 or 4), of polyester which is coated on both sides with a thermally activated catalyst adhesive by which the laminated structure is adhered. This polyester acts as a reinforcing layer preventing element 19 "breaking out" of the PVC layers 23 and 24.

The fabrication process of the card illustrated in Figures 2, 3 and 4 begins with a substrate sheet 12 of copper-clad epoxy/glass which is etched to form a large number of identical printed circuits 13, each as illustrated in Figure 5. On top of each printed circuit is printed a thermoset dielectric material indicated by the shaded regions 15, 16 which is cured in place. The function of circular part 15 is explained below. The linear part 16 serves as an insulator to separate printed conductive link 17 between inner and outer ends of a coil 14 defined by part of the printed circuit 13.

- 6 -

Separated from a main part of the substrate by lines of weakness not shown are a number of strips (not shown), each carrying printed patterns 25 (only one of which is illustrated), with apertures 26 therein, which ultimately become the top reinforcing caps of the elements 19.

The substrate carrying the etched patterns is placed on a bed of a screen printing machine (not shown) and a screen placed over it. A squeegee is then used to print a low ionic epoxy encapsulant/adhesive material onto positions 27 as shown in Figure 6. This is a mixture of a resin and a catalyst which sets hard when cured. Suitable materials are, for example, available from Ablestick, Encaremix, or Dexter Hisol. The substrate is then placed in a "pick-and-place" machine which places components comprising of capacitors 28 and silicon chips 29, shown in Figure 7, onto the epoxy which acts as an adhesive to hold them in place. The silicon chips 29 at this stage are "naked", that is to say they are not encapsulated. A notable feature of this process is that the epoxy is applied to areas where there is no copper layer, this being unnecessary because of the adhesive attachment of the components. A saving of 35 microns in thickness is thus achieved as compared with arrangements where components are soldered on top of a copper track. It will be appreciated that this reduction of thickness may be of crucial importance in situations where there may typically be a requirement for the entire assembly not to exceed 760 microns. An advantage of using epoxy adhesive is that if suitably selected it remains in its adhesive state for a sufficient time period which exceeds the maximum period during which the screen printing machine is not being operated. This avoids the need to

- 7 -

clean down the equipment.

The sheet substrate carrying the etched patterns and respective components positioned on it, is then baked until the epoxy has gelled, i.e. set but not hardened. This takes place under a flow of nitrogen to prevent oxidation of the copper. The sheet is then placed on the work-holder of a wire bonding machine where it is held in position by a vacuum. Suitable machines for this purpose are commercially available. Wire connections are then made between contacts on the individual components to appropriate parts of the printed copper circuitry. This is done by an ultrasonically assisted diffusion welding process. The sheet is then placed back in the screen printer with a different stencil in place. This stencil is much thicker, its thickness being selected so that the same epoxy encapsulant/adhesive now to be deposited over the components is sufficient to cover them completely. Notably, this material is the same as that which was used for the adhesive. It does not have to be the same but it preferably has similar physical characteristics. After the removal of the stencil, the sheet is as shown in Figure 8, the components being encapsulated by the encapsulant 30.

Figure 9 shows in cross-section the next stage of the process where a copper spacer 31 having a plurality of apertures 32 (corresponding to each of the regions on the sheet having encapsulant 30 deposited thereon) is located on the sheet, 12. Previously placed on the copper sheet is each of the now separated strips 33, previously referred to, to form regions defined by printed patterns 25, from which

- 8 -

regions reinforcing caps 22 will be formed. The spacer 31, with strips 33 located on it by means of pins (not shown for clarity), has been placed on top of the substrate. The whole arrangement is then pressed such that the patterns 25 are pressed into contact with the spacer 31 which is thus pressed closely down onto the circular part 16 of the dielectric material. It also presses the portions of the strip 33 defined by the patterns 25 onto the, still soft, epoxy encapsulant/adhesive thereby pulling the entire assembly down to the desired height. During this process the encapsulant spreads out as shown in detail in Figure 10, but not as far as the edges of the spacer sheet. It is prevented from doing so by its meniscus acting against the inner edges of the copper pattern 25 and dielectric ring 16, which meniscus thereby defines the radius of the encapsulant.

The whole assembly is now placed in an oven and cured at a temperature of 150°C. This fully gels the encapsulant/adhesive both under the components and the encapsulant portion. The assembly is now placed on a rule die which forms cuts 34 which can be seen in Figure 3. These cuts are "horseshoe-shaped" and configured so that their free ends correspond with the slots 26 (see Figure 5) in the strip 33. Note at this stage that the ends of each cut are located on the copper pads 35 of Figure 3. The cutter presses through the structure as illustrated by dotted lines 36 in Figure 10, leaving the element 19 on a limb of the substrate 11, as is best seen from Figure 3, and leaving the spacer 31 and remaining portions of the strips 33 free to be removed.

- 9 -

It will be noted from Figure 3 that the electrical connections to the element run parallel to an edge of the card, in which direction the card is most resistant to bending, as opposed to across the hinge line which runs across the corner of the card where it is most susceptible to bending.

Using another rule die, cruciform shapes are cut out of the assembly to give each printed circuit the shape 41 illustrated in Figure 3. This removes the epoxy/glass substrate from those areas which are to become the corners of the finished cards. It is notably these corner parts which are most subject to the type of manipulation which encourages de-lamination.

The printed circuit 1 with reinforced element 19 is now placed, as shown in Figure 11, between two outer sheets 37 and 38 of thermo plastics material in the pvc family with the inter-position of polyester layers coated on both sides with a thermally activated catalyst adhesive 21. The assembled sandwich is placed in a press where it is heated to cause lamination. During this stage the capsules 18 imbed themselves in each of the sheets of thermo-plastic material in such a way as to tend to centralise themselves between opposite faces leaving the plane of the substrate sheet 1 on the central axis as shown in Figure 4. The press now opens and the assembly is removed to a cutting machine where the individual cards as illustrated in Figures 2 and 3 are cut out.

**CLAIMS**

1. A method of manufacturing a card comprising a printed circuit sandwiched between protective layers, the method comprising: removing portions of a substrate of the printed circuit in regions to correspond to the periphery of the card; sandwiching the printed circuit between the protective layers, which layers extend over the regions where the portions have been removed; bonding the protective layers and substrate together; and cutting the card out of the protective layers, the cut extending through the substrate in those regions of the periphery where the substrate has not previously been removed.
2. A method as claimed in claim 1 where the portions are removed by stamping.
3. A method as claimed in claim 1 or 2 wherein the card is cut out by stamping.
4. A method as claimed in any preceding claim wherein a number of circuits are formed on a common substrate, and the portions are removed simultaneously from all the circuits.
5. A method as claimed in any preceding claim wherein the cards are polygonal and the portions removed correspond to the corner portions.
6. A method as claimed in any preceding claim wherein a plurality of rectangular



- 11 -

cards are formed from a single substrate and cruciform portions are removed corresponding to corner regions of adjacent cards.

7. A method as claimed in any preceding claim wherein the protective layers are bonded to each other in the regions from which the portions of the substrate have been removed.

8. A method as claimed in any preceding claim comprising inserting intervening layers between the substrate and the protective layers, the intervening layers being coated in adhesive which bonds the layers together.

9. A method as claimed in claim 8 wherein the intervening layers are polyester.

10. A method substantially as hereinbefore described with reference to Figures 2 to 11 of the accompanying drawings.

11. A card produced in accordance with a method as claimed in any one of claims 1 to 10.

Patents Act 1977  
 Examiner's report to the Comptroller under Section 17  
 (The Search report)

Application number  
 GB 9313757.8

**Relevant Technical Fields**

- (i) UK Cl (Ed.L) B6A (AK)  
 (ii) Int Cl (Ed.5) G06K

Search Examiner  
 G J W RUSSELL

Date of completion of Search  
 27 OCTOBER 1993

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(ii)

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